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NOTICE: Document is attached. This document supersedes EC-100-20-D, *Interconnection for Conventional Balloon Flights*.

Remove this page before printing/distributing to users or posting on the CSBF web site.

CHANGE LOG

CHANGE SUMMARY	REVISION	DATE OUT FOR REVIEW
Baseline Release	A	April 20, 2007
Removed references to channels 1 and 3 from the Voltage-Controlled Oscillators section on page	B	February 11, 2008
Added more information for VCO Frequency Response to Table 2	C	October 25 2011

COLUMBIA SCIENTIFIC BALLOON FACILITY

CONVENTIONAL BALLOON OPERATIONS SUPPORT

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CONTRACT NO. NAS5-03003

CONSOLIDATED INSTRUMENT PACKAGE (CIP) INTERFACE USER HANDBOOK

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NEW MEXICO STATE UNIVERSITY
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GLOSSARY

ASCII	American Standard Code for Information Interchange; a code for representing alphanumeric information
ATC	Air Traffic Control
BPO	Balloon Program Office
CIP	Consolidated Instrument Package
CSBF	Columbia Scientific Balloon Facility
GMT	Greenwich mean time
GPS	global positioning system
GSE	Ground Station Equipment
IRIG	Inter-Range Instrumentation Group
NASA	National Aeronautics and Space Administration
NMSU	New Mexico State University
PCM	pulse code modulation

INTRODUCTION

The Columbia Scientific Balloon Facility (CSBF) provides the science user with electronic flight support equipment for telemetry, command, and tracking. CSBF personnel are also available to assist the user with equipment interface and to provide information about CSBF electronics capabilities.

CSBF has developed a command and data acquisition system currently used routinely in the balloon program. User interface and balloon control is accomplished by several mature electronic systems. These systems retrieve scientific data, as well as provide the essential control functions for safe and successful ballooning.

The Consolidated Instrument Package (CIP) is the command and data acquisition system used on conventional balloon flights. The CIP is a self-contained electronics package that can be easily configured to fit the individual needs of different science groups. It fulfills the functional requirements of transmitting CSBF housekeeping and user-generated analog or digital data, and it receives science and balloon control commands sent from the control tower or tracking aircraft.

The CIP is comprised of a card rack containing printed circuit boards that provide the means for receiving and decoding commands, subcarrier oscillators, PCM (pulse code modulation) encoder, dual GPS (global positioning system) receivers, pressure transducers, ATC (Air Traffic Control) transponder, and L- or S-band transmitters.

This document presents information to science users on communication requirements and standards used with the CIP.

ONBOARD INTERFACE

J2 CONNECTOR

Consolidated instrument package (CIP) commanding uses a 16-bit data word and 77 available discrete commands (10 through 5C hexadecimal). These commands are accessible on the CIP J2 connector as open collector outputs with a maximum rating of 500-ma continuous and maximum 50-V pull-up voltage.

Note
An in-line current limiting resistor is also required.

Figure 1 illustrates the J2 connector.

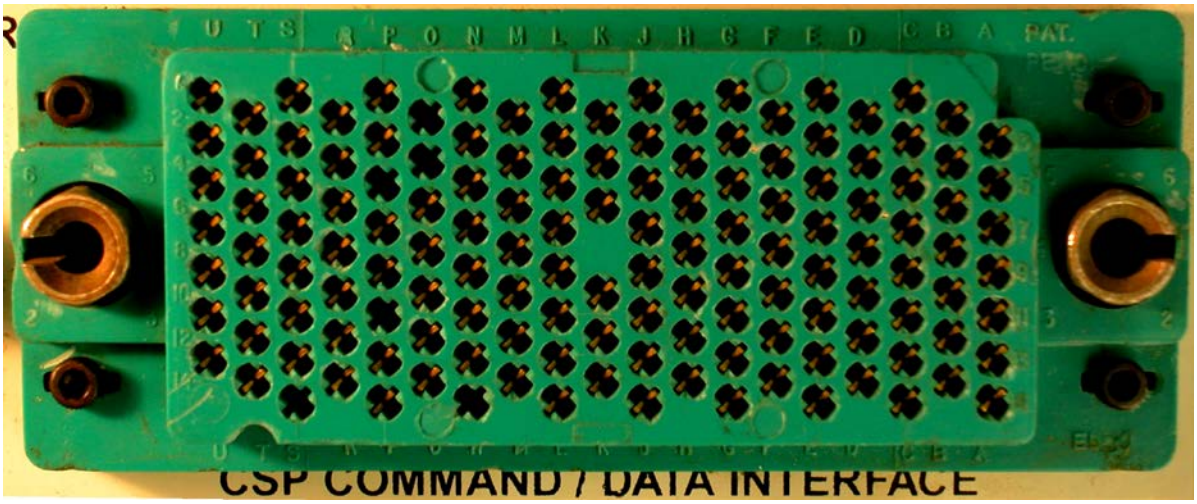

Figure 1. CIP J2 140-Pin Connector

CONNECTOR PINOUTS

Connector pinouts are listed in Table 1.

Table 1. CIP J2 Connector Pinouts

PIN	NAME	DESCRIPTION	PIN	NAME	DESCRIPTION
A3	DWB0	Data word bit 0	D14	CMD1A	Command 1A
A5	DWB1	Data word bit 1	E1	CMD1B	Command 1B
A7	DWB2	Data word bit 2	E3	CMD1C	Command 1C
A9	DWB3	Data word bit 3	E5	CMD1D	Command 1D
A11	DWB4	Data word bit 4	E7	CMD1E	Command 1E
A13	DWB5	Data word bit 5	E9	CMD1F	Command 1F
A15	DWB6	Data word bit 6	E11	CMD20	Command 20
B2	DWB7	Data word bit 7	E13	CMD21	Command 21
B4	DWB8	Data word bit 8	E15	CMD22	Command 22
B6	DWB9	Data word bit 9	F2	CMD23	Command 23
B8	DWB10	Data word bit 10	F4	CMD24	Command 24
B10	DWB11	Data word bit 11	F6	CMD25	Command 25
B12	DWB12	Data word bit 12	F8	CMD26	Command 26
B14	DWB13	Data word bit 13	F10	CMD27	Command 27
C1	DWB14	Data word bit 14	F12	CMD28	Command 28
C3	DWB15	Data word bit 15	F14	CMD29	Command 29
C5	STROBELO	Strobe low; 1-millisecond negative-going pulse	G1	CMD2A	Command 2A
C7	STROBEHI	Strobe high; 1-millisecond positive-going pulse	G3	CMD2B	Command 2B
			G5	CMD2C	Command 2C
C9	CMD10	Command 10	G7	CMD2D	Command 2D
C11	CMD11	Command 11	G9	CMD2E	Command 2E
C13	CMD12	Command 12	G11	CMD2F	Command 2F
C15	CMD13	Command 13	G13	CMD30	Command 30
D2	CMD14	Command 14	G15	CMD31	Command 31
D4	CMD15	Command 15	H2	CMD32	Command 32
D6	CMD16	Command 16	H4	CMD33	Command 33
D8	CMD17	Command 17	H6	CMD34	Command 34
D10	CMD18	Command 18	H8	CMD35	Command 35
D12	CMD19	Command 19	H10	CMD36	Command 36

PIN	NAME	DESCRIPTION
H12	CMD37	Command 37
H14	CMD38	Command 38
J1	CMD39	Command 39
J3	CMD3A	Command 3A
J5	CMD3B	Command 3B
J7	CMD3C	Command 3C
J9	CMD3D	Command 3D
J11	CMD3E	Command 3E
J13	CMD3F	Command 3F
J15	CMD40	Command 40
K2	CMD41	Command 41
K4	CMD42	Command 42
K6	CMD43	Command 43
K10	CMD44	Command 44
K12	CMD45	Command 45
K14	CMD46	Command 46
L1	CMD47	Command 47
L3	CMD48	Command 48
L5	CMD49	Command 49
L7	CMD4A	Command 4A
L9	CMD4B	Command 4B
L11	CMD4C	Command 4C
L13	CMD4D	Command 4D
L15	CMD4E	Command 4E
M2	CMD4F	Command 4F
M4	CMD50	Command 50
M6	CMD51	Command 51
M8	CMD52	Command 52
M10	CMD53	Command 53
M12	CMD54	Command 54
M14	CMD55	Command 55
N1	CMD56	Command 56
N3	CMD57	Command 57

PIN	NAME	DESCRIPTION
N5	CMD58	Command 58
N7	CMD59	Command 59
N9	CMD5A	Command 5A
N11	CMD5B	Command 5B
N13	CMD5C	Command 5C
N15		Not used
O2		Not used
O4		Not used
O6	CMDVER	Command verify
O8	CH. HH IN	VCO channel HH input
O10	CH. B IN	VCO channel B input
O12	CH. 9 IN	VCO channel 9 input
O14	TO J3-AZ	CSBF use interconnect
P1	CH. 7 IN	VCO channel 7 input
P3	CH. 8 IN	VCO channel 8 input
P5		Not used
P7	CH. 5 IN	VCO channel 5 input
P9	CH. E IN	VCO channel E input
P11	MKSBUFFOUT	CSBF use
P13	MKSHI/LO BIT	CSBF use
P15	MKS LO BIT	CSBF use
R2	MKS MID BIT	CSBF use
R4	MKS HI BIT	CSBF use
R6	GND	Ground
R8	GND	Ground
R10	GND	Ground
R12	CSBF I/O 1	CSBF interconnect to J3
R14	CSBF I/O 2	CSBF interconnect to J3
S1	CSBF I/O 3	CSBF interconnect to J3
S3	CSBF I/O 4	CSBF interconnect to J3
S5	GPS#1 1PPS	GPS #1 one-pulse-per-second
S7	GPS#2 1PPS	GPS #2 one-pulse-per-second
S9	CSBF I/O 5	CSBF interconnect to J3

PIN	NAME	DESCRIPTION
S11	CSBF I/O 6	CSBF interconnect to J3
S13	CSBF I/O 7	CSBF interconnect to J3
S15		Not used
T2	CSBF I/O 8	CSBF interconnect to J3
T4	CSBF I/O 9	CSBF interconnect to J3
T6	CSBF I/O 10	CSBF interconnect to J3
T8	CSBF I/O 11	CSBF interconnect to J3
T10	CSBF I/O 12	CSBF interconnect to J3
T12	CSBF I/O 13	CSBF interconnect to J3

PIN	NAME	DESCRIPTION
T14	CSBF I/O 14	CSBF interconnect to J3
U1	CSBF I/O 15	CSBF interconnect to J3
U3	CSBF I/O 16	CSBF interconnect to J3
U5	CSBF I/O 17	CSBF interconnect to J3
U7	GND	Ground
U9	GND	Ground
U11	GND	Ground
U13	GND	Ground

DISCRETE COMMANDS

The discrete commands are set up to output a “low” (an activated open collector driver) when the command is sent.

DATA WORD

Data word bits on J2 are pins A3 through C3. The data word is set up to output a “high” (a non-activated open collector driver) when the data word bit is sent true or “high”.

For example, if all bits are sent true with a data word command of FFFF, all bits would be seen as high with non-activated open collector drivers.

When there is valid data on the 16 data word bits, the strobe pins (C5 and C7) pulse for one millisecond (*STROBEHI* goes high and *STROBELO* goes low).

VOLTAGE-CONTROLLED OSCILLATORS

Voltage-controlled oscillators are available in standard IRIG (Inter-Range Instrumentation Group) channels 5, 7, 8, 9, B, E, and HH. Table 2 lists the impedances and input ranges.

Table 2. VCO Impedance and Input Range

VCO CHANNEL	IMPEDANCE	INPUT RANGE	FREQUENCY RESPONSE	MAX NRZ BAUD RATE
5	500-Kohms	0 to +5 V	196 Hz	150
7	500-Kohms	0 to +5 V	346 Hz	150
8	500-Kohms	0 to +5 V	450 Hz	300
9	500-Kohms	0 to +5 V	586 Hz	300
B	250-Kohms	0 to +5 V	9000 Hz	4800
E	250-Kohms	0 to +5 V	21000 Hz	9600
HH	250-Kohms	0 to +5 V	99500 Hz	70,000

TELEMETRY TRANSMITTERS

Two types of telemetry transmitters are available for use. The first is a digital transmitter requiring a 0-V to +5-V input. The second requires a bipolar input, with the amplitude dependent upon the bit rate being used. Table 3 lists the optimum analog transmitter modulation voltages for typical data rates.

Table 3. Optimum Analog Transmitter Modulation Voltage

OPTIMUM BI0 DEVIATION			OPTIMUM NRZ DEVIATION		
BIT RATE (KBS)	DEVIATION (KHZ)	MODULATION (VP-P)	BIT RATE (KBS)	DEVIATION (KHZ)	MODULATION (VP-P)
0-150	97.5	0.55	0-250	87.5	0.49
200	130.0	0.73	300	105.0	0.59
250	162.5	0.91	350	122.5	0.69
300	195.0	1.09	400	140.0	0.78
333	216.5	1.21	450	157.5	0.88
			500	175.0	0.98
			550	192.5	1.08
			600	210.0	1.18
			650	227.5	1.27
			700	245.0	1.37
			740	259.0	1.45

GROUND STATION EQUIPMENT INTERFACE

PORT CONFIGURATION

DEFAULT

The default port configuration is shown in Table 4:

Table 4. Default Port Configuration

ITEM	SETTING
Baud rate	1200
Parity	None
Bits	8
Stop bit	1

Available baud rates include 1200, 2400, 4800, 9600. Baud rate does NOT affect the rate of outgoing commands.

USER COMMANDS

REQUEST PACKET

The user command request packet is sent from the user's computer to the CSBF ground station equipment computer.

> **Note**
>
> Users are not allowed to command CSBF balloon control systems.

PACKET FORMAT

Use this format to request that user commands be sent to the CIP/payload.

Syyyy(SP)xxqSyyyy(SP)xxqSyyyy(SP)xxq(CR)(LF)

Where:

S	=		ASCII 53h
yyyy	=	four-character command	hex for data word and discrete
(SP)	=	space	ASCII 20h
xx	=	address in hex	
q	=	W for data word	ASCII 57h
		or	
		K for discrete	ASCII 4Bh
(CR)	=	carriage return	ASCII 13h
(LF)	=	line feed	ASCII 10h

EXAMPLES Discrete Command for Address 12h, Command 13h

```
S0013 12KS0013 12KS0013 12K(CR)(LF)
```

Data Word Command for Address 12h, Command AB03h

```
SAB03 12WSAB03 12WSAB03 12W(CR)(LF)
```

VERIFICATION PACKET

The CSBF command management system will return this packet to the user to verify that a user command request packet has been received AND that the command has been sent.

> **Note**
>
> *Receipt of this packet does not verify that the command was received by the CIP, only that the command was sent to the transmitter.*

```
XX/YYYY/00:00:00(CR)(LF)
```

Where:

XX	=	Address in hex
/	=	ASCII 2Fh
YYYY	=	Command in hex
00:00:00	=	Time the command was sent (GMT)
(CR)	=	Carriage return (ASCII 13h)
(LF)	=	Line feed (ASCII 10h)

ERROR MESSAGES

Error messages will be returned if the command is not formatted properly. The error messages are formatted as shown in table x.

Table 5. Error Message Formats

MESSAGE	DESCRIPTION
S-ERROR(SP)00:00:00(CR)(LF)	General error
C-ERROR(SP)00:00:00(CR)(LF)	Address greater than 1Fh
1-ERROR(SP)00:00:00(CR)(LF)	Repetitions not equal

EXAMPLES Table 6 contains examples of properly formatted commands sent from the Science ground station equipment.

Table 6. Properly Formatted Science GSE Commands

COMMAND	DESCRIPTION
12/0013/12:20:45(CR)(LF)	Address 12h, command 13h
12/AB03/12:20:46(CR)(LF)	Address 12h, command AB03h

Table 7 contains an example of an error message received for unequal repetitions.

Table 7. Sample Error Message

MESSAGE	DESCRIPTION
1-ERROR 12:20:50(CR)(LF)	Repetitions not equal

USER SINGLE-LINE INTERFACE

This section outlines the format for an optional single-line interface which passes balloon location and command echo information to the user. The information is sent on the same serial line used by the user command interface and does not interfere with this capability. The normal user command verification packet is still provided to the user, in addition to the command echo data.

CIP LOCATION INTERFACE

If the single-line interface is enabled, this information is sent to the user at 5- or 10-second intervals. If the selected GPS is updating, a packet will be sent every time a GPS packet is received (roughly every 5 seconds). If the selected GPS is not updating, a packet will be sent every 10 seconds with the last data received from the CIP.

PACKET FORMAT

The packet format is defined as follows:

```
HH:MM:SSLLLLLmmm.mLLLLLmmm.maaaaaaaapppppp.
ppprrrrrrssssshhhhttttttt.t(CR)(LF)
```

Where:

HH:MM:SS	=	Time (GMT)	(00:00:00)
LLLLLmmm.m	=	Latitude (degrees minutes.decimal_ seconds)	(%5d%5.1f)
LLLLLmmm.m	=	Longitude (degrees minutes. decimal_seconds)	(%5d%5.1f)
aaaaaaaa	=	GPS altitude (ft)	(%8d)
pppppp.ppp	=	Pressure altitude (millibars)	(%10.3f)
rrrrrr	=	GPS ascent rate (ft/min)	(%6d)
ssss	=	GPS speed (knots)	(%4d)
hhhh	=	GPS heading (degrees)	(%4d)
ttttt.t	=	Air temperature (°C)	(%8.1f)
(CR)	=	Carriage return	(ASCII 13h)
(LF)	=	Line feed	(ASCII 10h)

EXAMPLES An example of the packet format is shown in Figure 2.

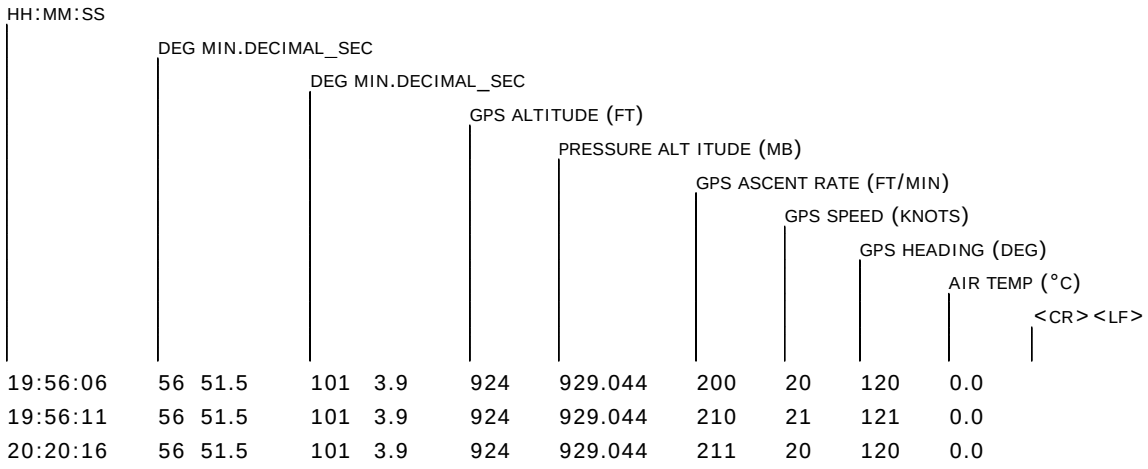

Figure 2. CIP Location Interface Packet Example

CIP COMMAND ECHO

COMMAND ECHO FORMAT

If the single-line interface is enabled, every command echo received from the CIP will be sent to the user in the format described below. The command echo indicates the last command received by the CIP.

Data word commands are sent in two stages with the lower byte being sent before the upper byte. This will cause two command echoes to be returned for every data word sent.

```
ECHO/XX/YYYY/00:00:00*(CR)(LF)
```

Where:

ECHO	=	ASCII text to denote echo of command received by CIP
XX	=	address in hex
/	=	ASCII 2Fh
YYYY	=	command in hex
00:00:00	=	time command echo was received by GSE (GMT)
Asterisk	=	ASCII 2Ah
(CR)	=	carriage return (ASCII 13h)
(LF)	=	line feed (ASCII 10h)

EXAMPLES Table 8 contains examples of command echoes.

Table 8. CIP Command Echo Examples

EXAMPLE	COMMAND
Address 12h, Command 13h	ECHO/12/0013/13:54:34*(CR)(LF)
Address 12h, Command AB03h	ECHO/12/0103/13:54:35*(CR)(LF) lower byte of data word + 100_h ECHO/12/02AB/13:54:36*(CR)(LF) upper byte of data word + 200_h